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Sound Processor with Built-in 3-band Equalizer

BD37541FS

General Description

BD37541FS is a sound processor with built-in 3-band equalizer for car audio. The functions are stereo input selector (which can switch single and ground isolation input), input-gain control, main volume, loudness, 5ch fader volume and mixing input. Moreover, "Advanced switch circuit", which is an original ROHM technology, can reduce various switching noise (ex. No-signal, low frequency like 20Hz & large signal inputs). Also, "Advanced switch" makes control of microcomputer easier, and can construct a high quality car audio system.

Features

- Reduced switching noise of input gain control, mute, main volume, fader volume, bass, middle, treble, loudness, mixing by using advanced switch circuit.
- Built-in differential input selector that can make various combination of single-ended / differential input.
- Built-in ground isolation amplifier inputs, which is ideal for external stereo input.
- Built-in input gain controller reduces switching noise for volume of a portable audio input.
- Decreased number of external components due to built-in 3-band equalizer filter and loudness filter. It is possible to control Q, G_v, f_o of 3-band equalizer through I²C BUS control.
- It is possible to adjust the gain of the bass, middle, treble up to ±20dB with 1 dB step gain adjustment.
- It is equipped with output terminals for Subwoofer. Moreover, the stereo signal output of the front and rear can also be chosen by the I²C BUS control.
- Built-in mixing input.
- Energy-saving design resulting in low-current consumption is achieved by utilizing the Bi-CMOS process. It has the advantage in quality over scaling down the power heat control of the internal regulators.
- Input terminals and output terminals are organized and separately laid out to keep the signal flow in one direction which results in simpler and smaller PCB layout.
- It is possible to control the I²C BUS by 3.3V / 5V.

Applications

It is optimal for car audio systems. It can also be used for audio equipment of mini Compo, micro Compo, TV, etc.

Key Specifications

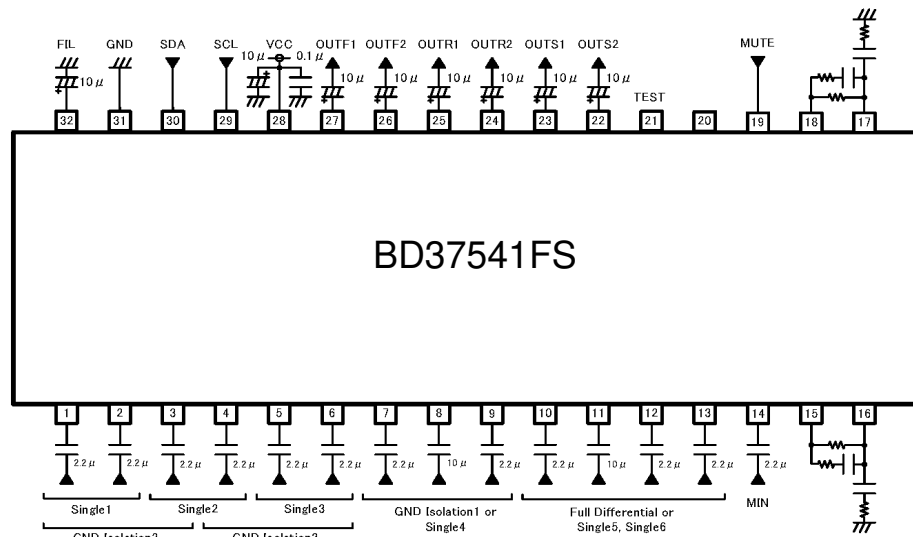
■ Power Supply Voltage Range:	7.0V to 9.5V
■ Circuit Current (No signal):	38mA(Typ)
■ Total Harmonic Distortion 1: (FRONT,REAR)	0.001%(Typ)
■ Total Harmonic Distortion 2: (SUBWOOFER)	0.002%(Typ)
■ Maximum Input Voltage:	2.3Vrms(Typ)
■ Cross-talk Between Selectors:	-100dB(Typ)
■ Volume Control Range:	+15 dB to -79dB
■ Output Noise Voltage 1: (FRONT,REAR)	3.8μVrms(Typ)
■ Output Noise Voltage 2: (SUBWOOFER)	4.8μVrms(Typ)
■ Residual Output Noise Voltage:	1.8μVrms(Typ)
■ Operating Temperature Range:	-40°C to +85°C

Package

W(Typ) x D(Typ) x H(Max)



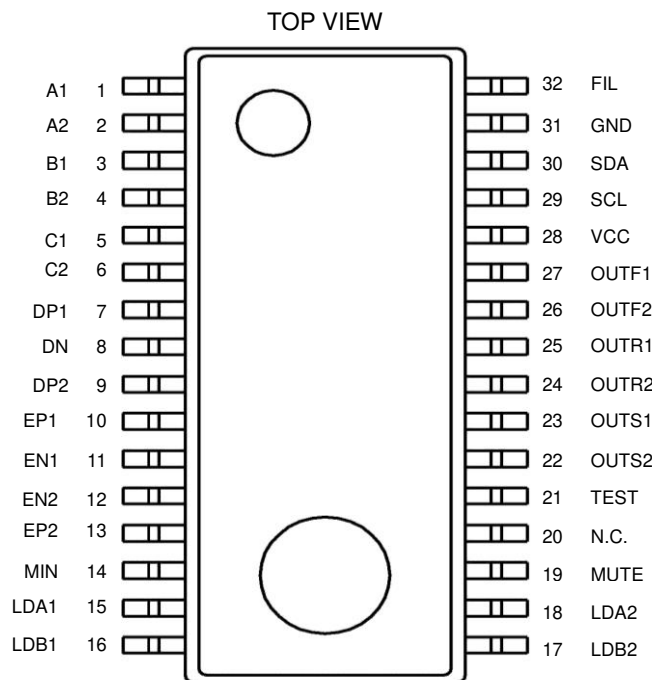
Typical Application Circuit



※About single input 1 to 3, it is possible to change from single input to GND Isolation input 2,3. ※About GND Isolation1 and Full Differential, it is possible to change from differential input to single input 4 to 6.

Unit
R : [Ω]
C : [F]

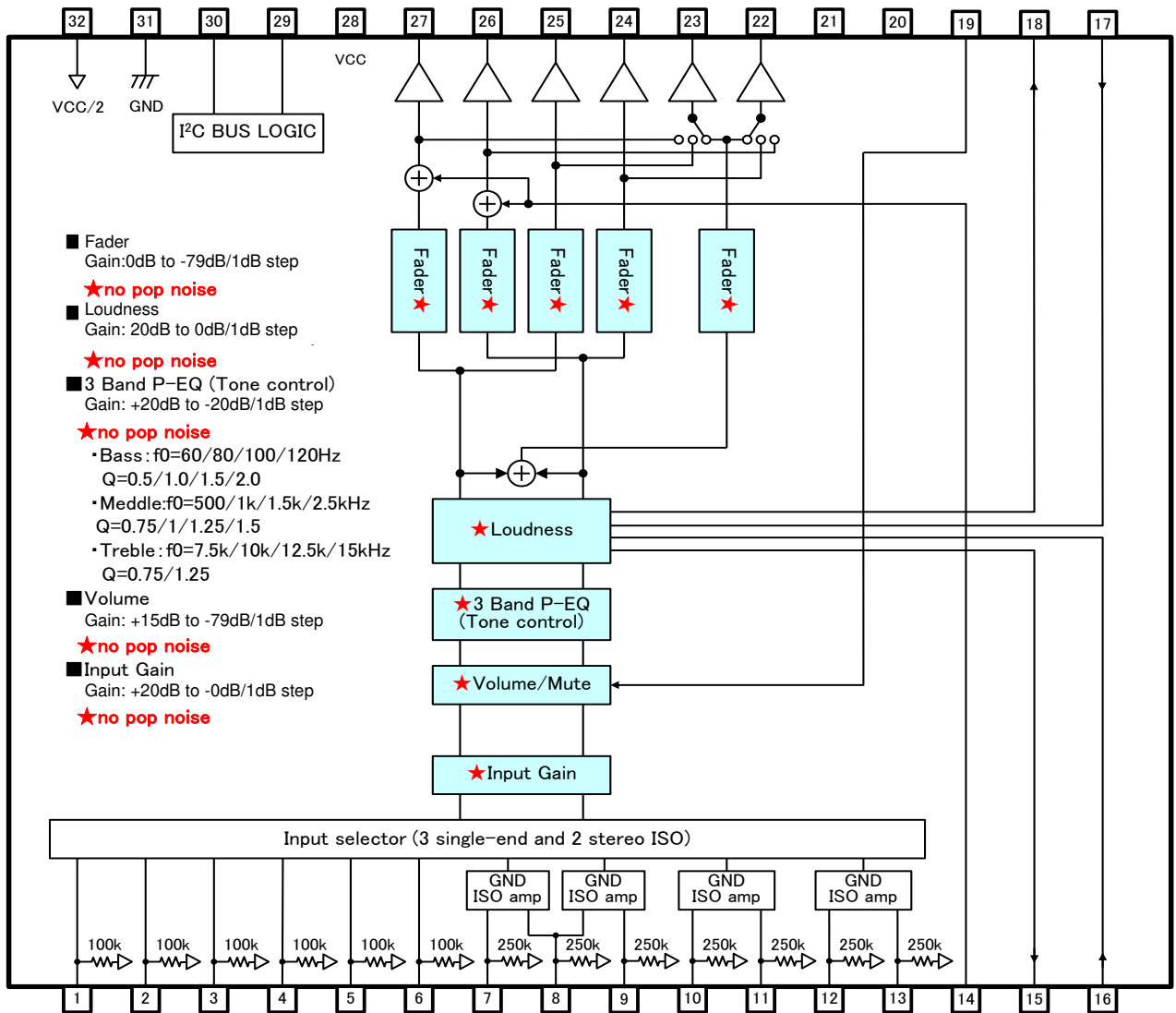
Pin Configuration



Pin Descriptions

Pin No.	Pin Name	Description	Pin No.	Pin Name	Description
1	A1	A input terminal of 1ch	17	LDB2	Loudness setting terminal of 2ch
2	A2	A input terminal of 2ch	18	LDA2	Loudness setting terminal of 2ch
3	B1	B input terminal of 1ch	19	MUTE	External compulsory mute terminal
4	B2	B input terminal of 2ch	20	N.C.	No Connection
5	C1	C input terminal of 1ch	21	TEST	Test Pin
6	C2	C input terminal of 2ch	22	OUTS2	Subwoofer output terminal of 2ch
7	DP1	D positive input terminal of 1ch	23	OUTS1	Subwoofer output terminal of 1ch
8	DN	D negative input terminal	24	OUTR2	Rear output terminal of 2ch
9	DP2	D positive input terminal of 2ch	25	OUTR1	Rear output terminal of 1ch
10	EP1	E positive input terminal of 1ch	26	OUTF2	Front output terminal of 2ch
11	EN1	E negative input terminal of 1ch	27	OUTF1	Front output terminal of 1ch
12	EN2	E negative input terminal of 2ch	28	VCC	Power supply terminal
13	EP2	E positive input terminal of 2ch	29	SCL	I ² C Communication clock terminal
14	MIN	Mixing input terminal	30	SDA	I ² C Communication data terminal
15	LDA1	Loudness setting terminal of 1ch	31	GND	GND terminal
16	LDB1	Loudness setting terminal of 1ch	32	FIL	VCC/2 terminal

Block Diagram



Absolute Maximum Ratings (Ta=25°C)

Parameter	Symbol	Rating	Unit
Power Supply Voltage	V _{CC}	10.0	V
Input Voltage	V _{IN}	V _{CC} +0.3 to GND-0.3	V
Power Dissipation	P _d	0.95 (Note 1)	W
Storage Temperature	T _{stg}	-55 to +150	°C

(Note 1) When mounted on the standard board (70 x 70 x 1.6 mm³), derate by 7.6mW/°C for Ta above 25°C.

Thermal resistance θ_{ja} = 131.6(°C/W)

Material : A FR4 glass epoxy board(3% or less of copper foil area)

Caution: Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.

Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Power Supply Voltage	V _{CC}	7.0	-	9.5	V
Temperature	Topr	-40	-	+85	°C

Electrical Characteristics

(Unless specified, Ta=25°C, V_{CC}=8.5V, f=1kHz, V_{IN}=1Vrms, R_g=600Ω, R_L=10kΩ, A1 input, Input gain 0dB, Mute OFF, Volume 0dB, Tone control 0dB, Loudness 0dB, Mixing OFF, Fader 0dB)

BLOCK	Parameter	Symbol	Limit			Unit	Conditions
			Min	Typ	Max		
GENERAL	Circuit Current (No Signal)	I _Q	-	38	48	mA	No signal
	Voltage Gain	G _V	-1.5	0	+1.5	dB	G _V =20log(V _{OUT} /V _{IN})
	Channel Balance	CB	-1.5	0	+1.5	dB	CB = G _{V1} -G _{V2}
	Total Harmonic Distortion 1 (FRONT,REAR)	THD+N1	-	0.001	0.05	%	V _{OUT} =1Vrms BW=400Hz-30KHz
	Total Harmonic Distortion 2 (SUBWOOFER)	THD+N2	-	0.002	0.05	%	V _{OUT} =1Vrms BW=400Hz-30KHz
	Output Noise Voltage 1 (FRONT,REAR) *	V _{NO1}	-	3.8	15	μVrms	R _g = 0Ω BW = IHF-A
	Output Noise Voltage 2 (SUBWOOFER) *	V _{NO2}	-	4.8	15	μVrms	R _g = 0Ω BW = IHF-A
	Residual Output Noise Voltage *	V _{NOR}	-	1.8	10	μVrms	Fader = -∞dB R _g = 0Ω BW = IHF-A
	Crosstalk Between Channels *	CTC	-	-100	-90	dB	R _g = 0Ω CTC=20log(V _{OUT} /V _{IN}) BW = IHF-A
Ripple Rejection	RR	-	-70	-40	dB	f=1kHz V _{RR} =100mVrms RR=20log(V _{CC} IN/V _{OUT})	
INPUT SELECTOR	Input Impedance(A, B,C)	R _{IN_S}	70	100	130	kΩ	
	Input Impedance(D, E)	R _{IN_D}	175	250	325	kΩ	
	Maximum Input Voltage	V _{IM}	2.1	2.3	-	Vrms	V _{IM} at THD+N(V _{OUT})=1% BW=400Hz-30KHz
	Crosstalk Between Selectors *	CTS	-	-100	-90	dB	R _g = 0Ω CTS=20log(V _{OUT} /V _{IN}) BW = IHF-A
	Common Mode Rejection Ratio *	CMRR	50	65	-	dB	XP1 and XN input XP2 and XN input CMRR=20log(V _{IN} /V _{OUT}) BW = IHF-A,[*X...D,E]

Electrical Characteristics - continued

BLOCK	Parameter	Symbol	Limit			Unit	Conditions
			Min	Typ	Max		
INPUT GAIN	Minimum Input Gain	G _{IN_MIN}	-2	0	+2	dB	Input gain 0dB V _{IN} =100mVrms G _{IN} =20log(V _{OUT} /V _{IN})
	Maximum Input Gain	G _{IN_MAX}	18	20	22	dB	Input gain 20dB V _{IN} =100mVrms G _{IN} =20log(V _{OUT} /V _{IN})
	Gain Set Error	G _{IN_ERR}	-2	0	+2	dB	G _{AIN} =+1dB to +20dB
MUTE	Mute Attenuation *	G _{MUTE}	-	-105	-85	dB	Mute ON G _{MUTE} =20log(V _{OUT} /V _{IN}) BW = IHF-A
VOLUME	Maximum Gain	G _{V_MAX}	13	15	17	dB	Volume = 15dB V _{IN} =100mVrms G _V =20log(V _{OUT} /V _{IN})
	Maximum Attenuation *	G _{V_MIN}	-	-100	-85	dB	Volume = -∞dB G _V =20LOG(V _{OUT} /V _{IN}) BW = IHF-A
	Attenuation Set Error 1	G _{V_ERR1}	-2	0	+2	dB	G _A IN & ATT=+15dB to -15dB
	Attenuation Set Error 2	G _{V_ERR2}	-3	0	+3	dB	ATT=-16dB to -47dB
	Attenuation Set Error 3	G _{V_ERR3}	-4	0	+4	dB	ATT=-48dB to -79dB
BASS	Maximum Boost Gain	G _{B_BST}	18	20	22	dB	Gain=+20dB f=100Hz V _{IN} =100mVrms G _B =20log(V _{OUT} /V _{IN})
	Maximum Cut Gain	G _{B_CUT}	-22	-20	-18	dB	Gain=-20dB f=100Hz V _{IN} =2Vrms G _B =20log(V _{OUT} /V _{IN})
	Gain Set Error	G _{B_ERR}	-2	0	+2	dB	Gain=-20dB to +20dB f=100Hz
MIDDLE	Maximum boost gain	G _{M_BST}	18	20	22	dB	Gain=+20dB f=1kHz V _{IN} =100mVrms G _M =20log(V _{OUT} /V _{IN})
	Maximum cut gain	G _{M_CUT}	-22	-20	-18	dB	Gain=-20dB f=1kHz V _{IN} =2Vrms G _M =20log(V _{OUT} /V _{IN})
	Gain set error	G _{M_ERR}	-2	0	+2	dB	Gain=-20dB to +20dB f=1kHz
TREBLE	Maximum Boost Gain	G _{T_BST}	18	20	22	dB	Gain=+20dB f=10kHz V _{IN} =100mVrms G _T =20log(V _{OUT} /V _{IN})
	Maximum Cut Gain	G _{T_CUT}	-22	-20	-18	dB	Gain=-20dB f=10kHz V _{IN} =2Vrms G _T =20log(V _{OUT} /V _{IN})
	Gain Set Error	G _{T_ERR}	-2	0	+2	dB	Gain=-20dB to +20dB f=10kHz
MIXING	Input Impedance	R _{IN_M}	19	27	35	kΩ	
	Maximum Input Voltage	V _{IM_M}	2.0	2.2	-	Vrms	V _{IM} at THD+N(V _{OUT})=1% BW=400Hz-30KHz
	Maximum Attenuation	G _{MX_MIN}	-	-100	-85	dB	MIX=OFF G _{MX} =20log(V _{OUT} /V _{IN}) BW=INF-A

Electrical Characteristics - continued

BLOCK	Parameter	Symbol	Limit			Unit	Conditions
			Min	Typ	Max		
FADER / SUBWOOFER	Maximum Attenuation *	G _{F_MIN}	-	-100	-90	dB	Fader = -∞dB G _F =20log(V _{OUT} /V _{IN}) BW = IHF-A
	Attenuation Set Error 1	G _{F_ERR1}	-2	0	+2	dB	ATT=-1dB to -15dB
	Attenuation Set Error 2	G _{F_ERR2}	-3	0	+3	dB	ATT=-16dB to -47dB
	Attenuation Set Error 3	G _{F_ERR3}	-4	0	+4	dB	ATT=-48dB to -79dB
	Output Impedance	R _{OUT}	-	-	50	Ω	V _{IN} =100mVrms
LOUDNE SS	Maximum Output Voltage	V _{OM}	2	2.2	-	Vrms	THD+N=1% BW=400Hz-30KHz
	Maximum Gain	G _{L_MAX}	17	20	23	dB	Gain 20dB V _{IN} =100mVrms G _L =20log(V _{OUT} /V _{IN})
	Gain Set Error	G _{L_ERR}	-2	0	+2	dB	GAIN=+1dB to +20dB

VP-9690A(Average value detection, effective value display) filter by Matsushita Communication is used for * measurement.
Phase between input / output is same.

Typical Performance Curves

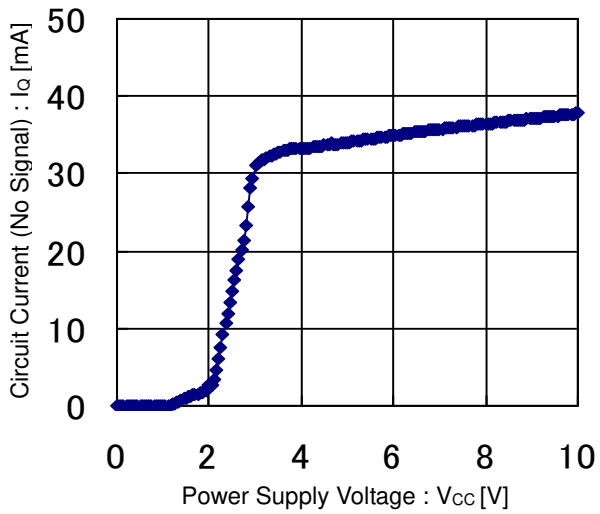


Figure 1. Circuit Current (No Signal) vs Power Supply Voltage

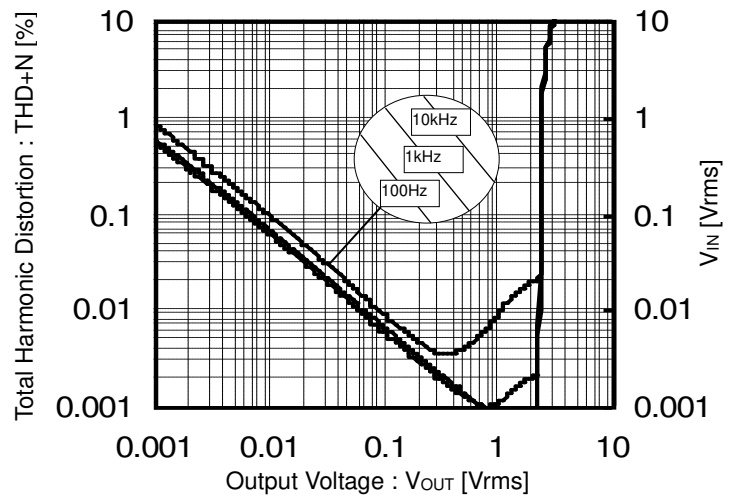


Figure 2. Total Harmonic Distortion vs Output Voltage

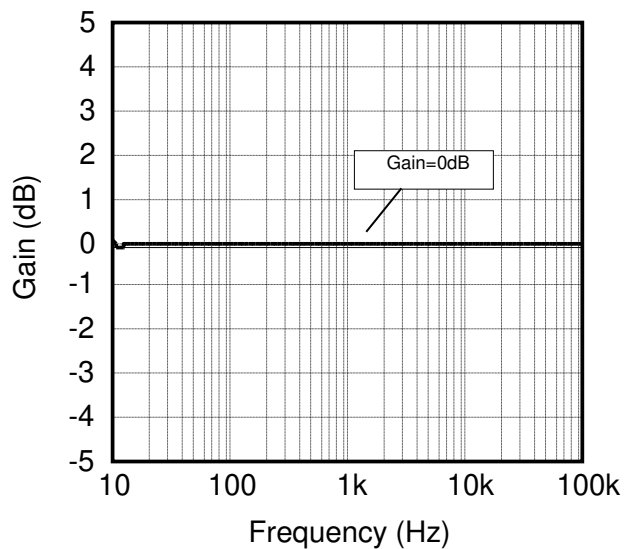


Figure 3. Gain vs Frequency

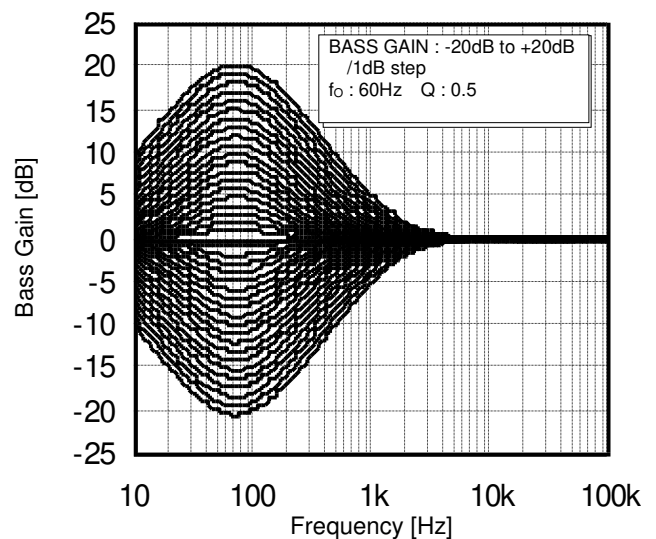


Figure 4. Bass Gain vs Frequency

Typical Performance Curves – continued

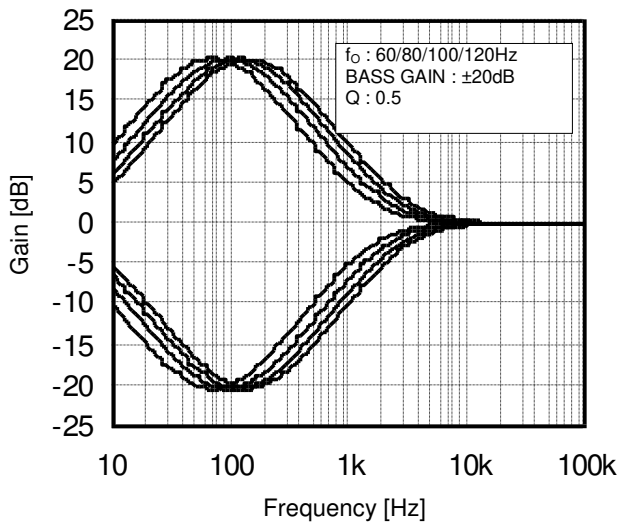


Figure 5. Bass f_o vs Frequency

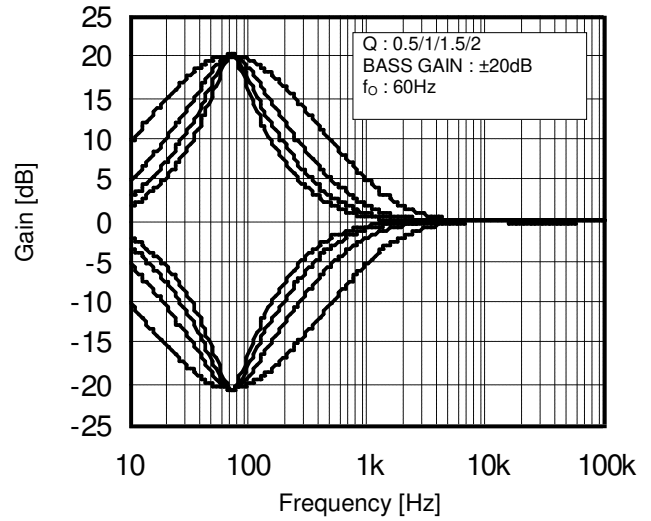


Figure 6. Bass Q vs Frequency

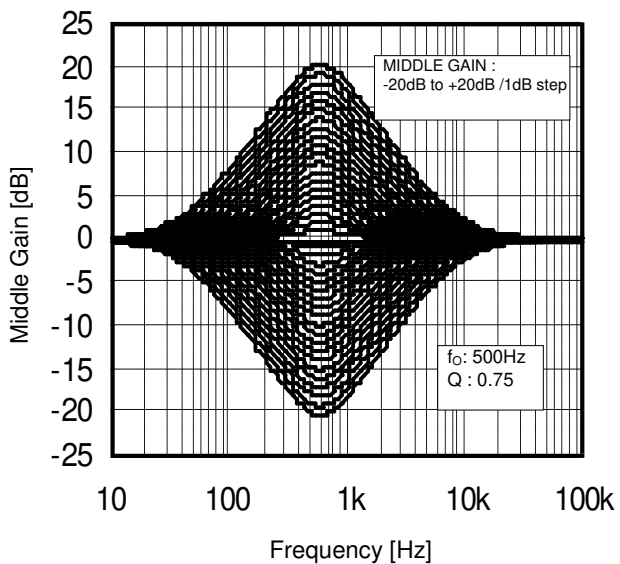


Figure 7. Middle Gain vs Frequency

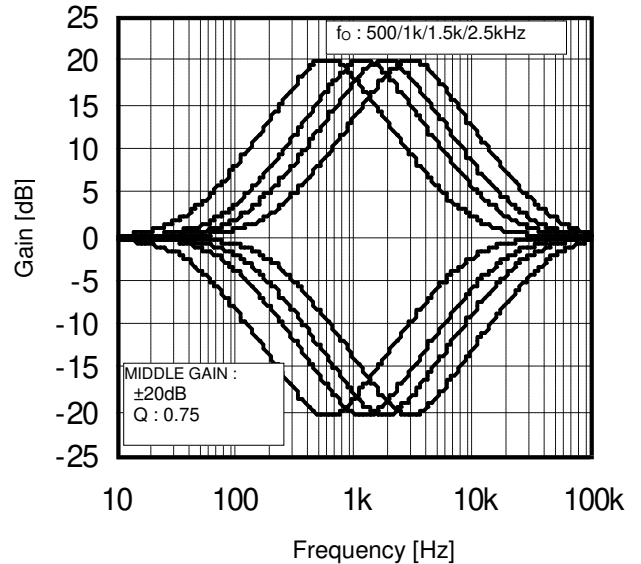


Figure 8. Middle f_o vs Frequency

Typical Performance Curves – continued

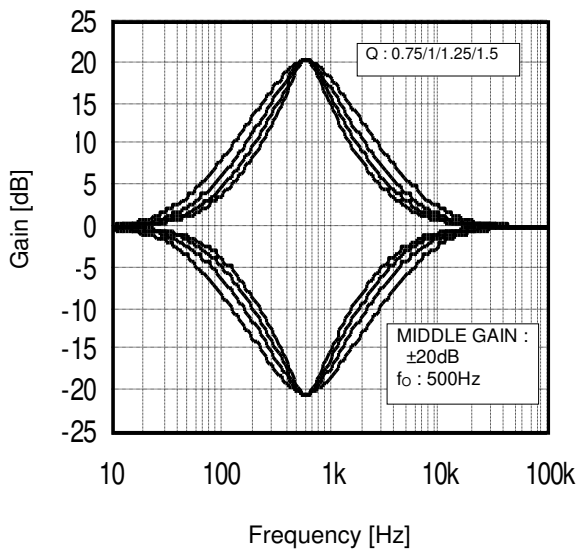


Figure 9. Middle Q vs Frequency

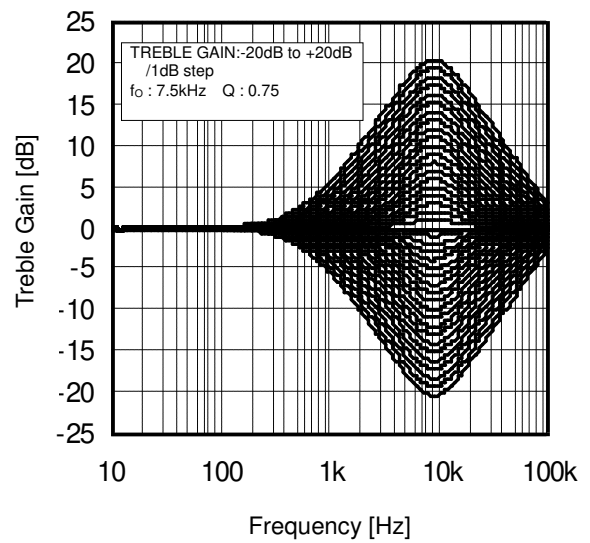


Figure 10. Treble Gain vs Frequency

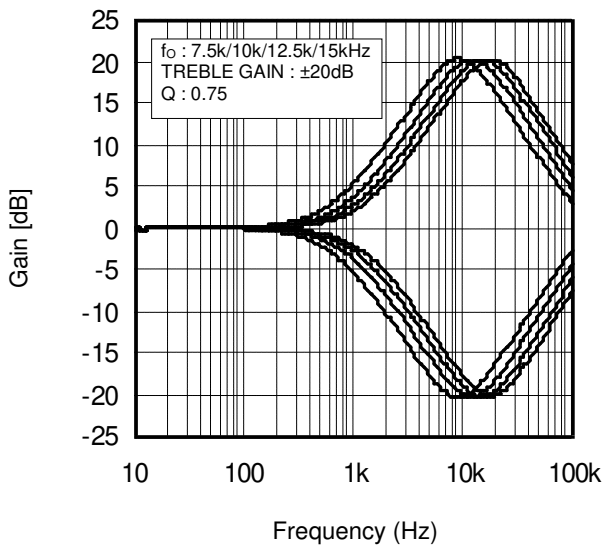


Figure 11. Treble f_o vs Frequency

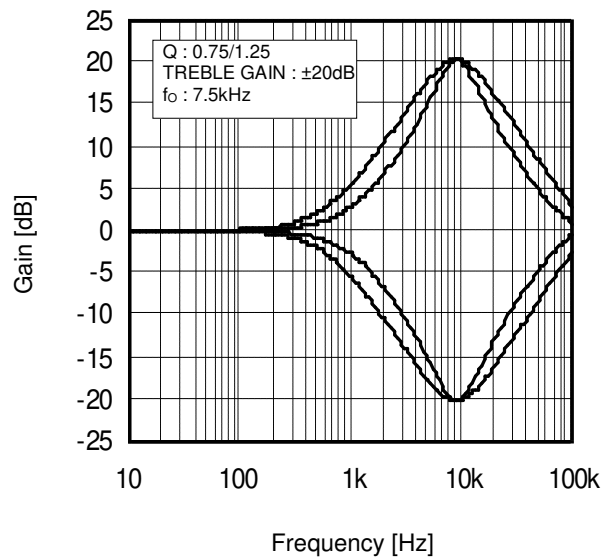


Figure 12. Treble Q vs Frequency

Typical Performance Curves – continued

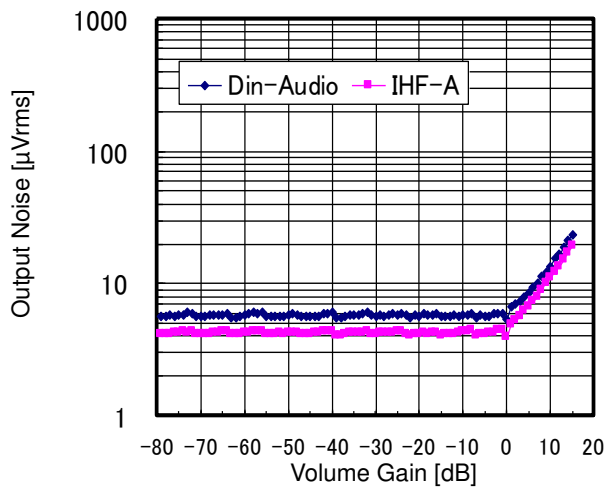


Figure 13. Output Noise vs Volume Gain

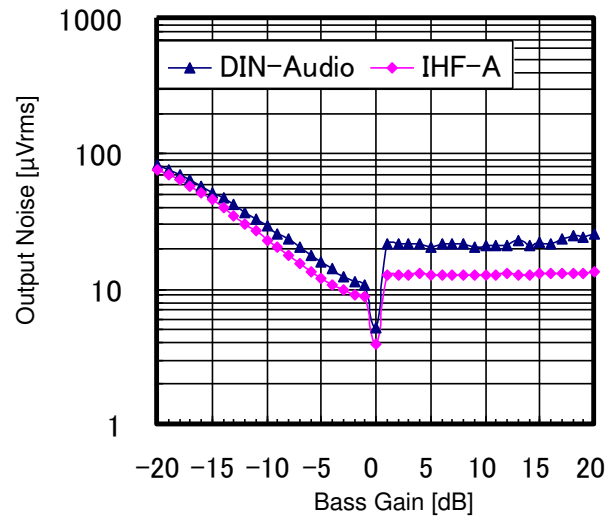


Figure 14. Output Noise vs Bass Gain

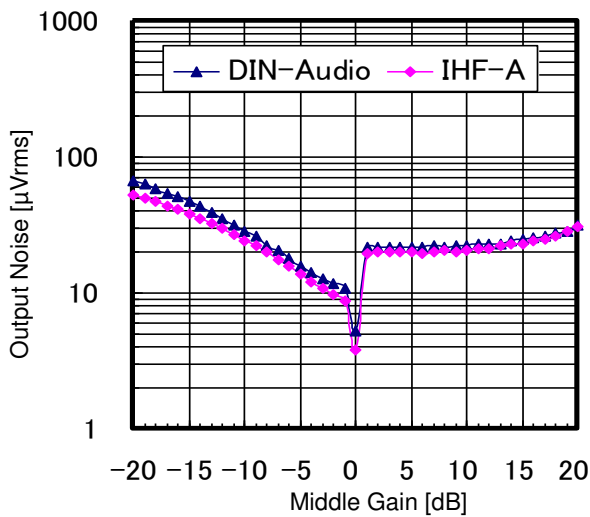


Figure 15. Output Noise vs Middle Gain

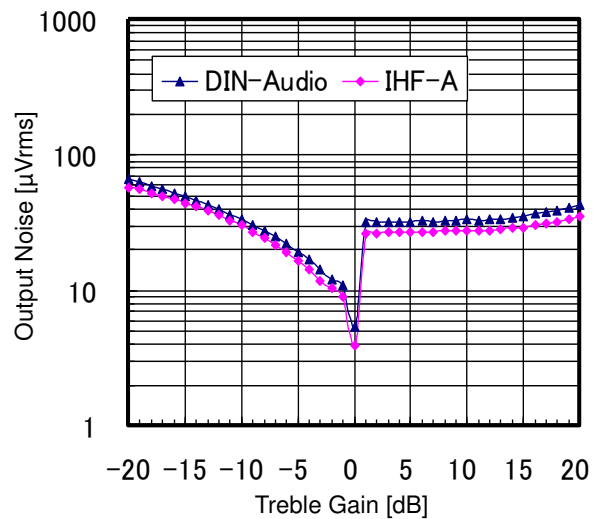


Figure 16. Output Noise vs Treble Gain

Typical Performance Curves – continued

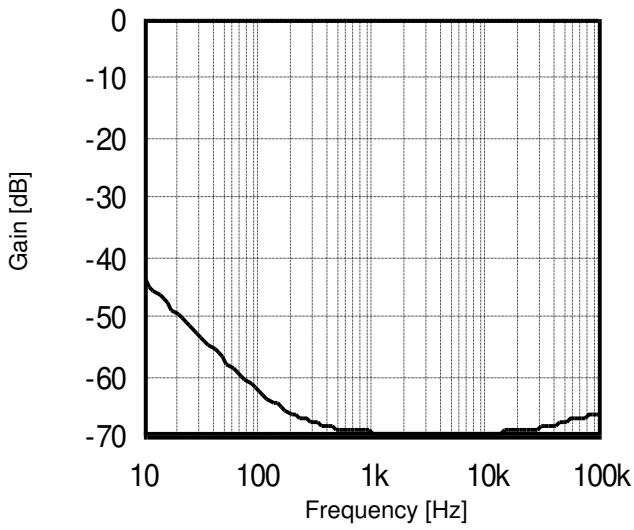


Figure 17. CMRR vs Frequency

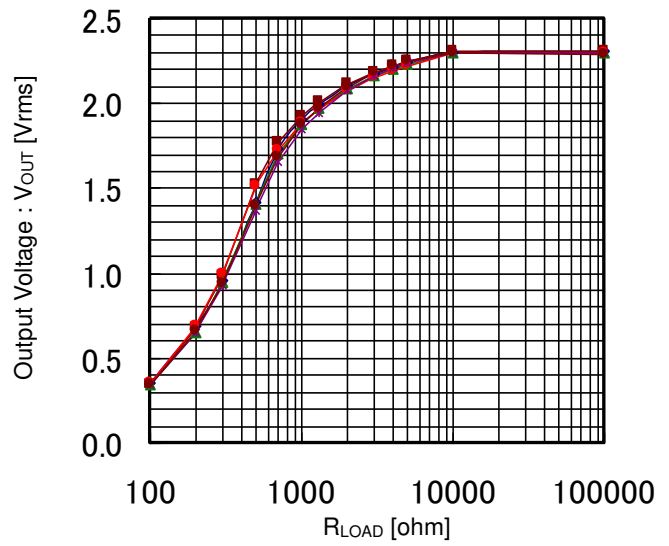


Figure 18. Output Voltage vs R_{LOAD}

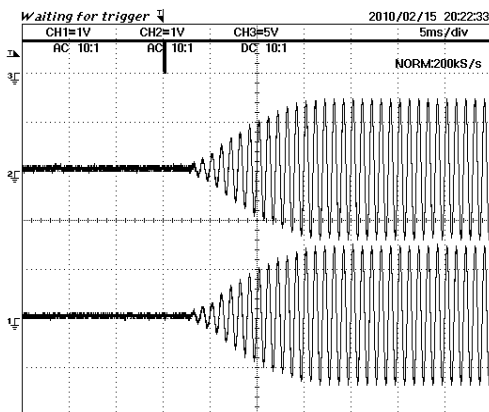


Figure 19. Advanced Switch 1

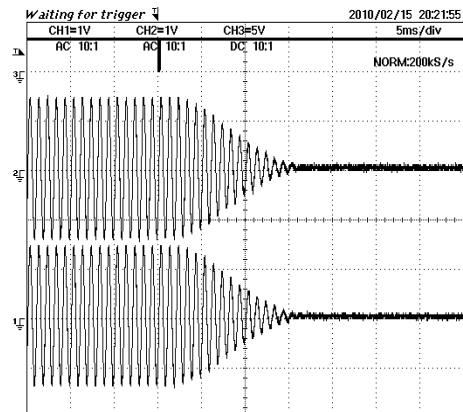


Figure 20. Advanced Switch 2

Timing Chart
CONTROL SIGNAL SPECIFICATION

(1) Electrical Specifications and Timing for Bus Lines and I/O Stages

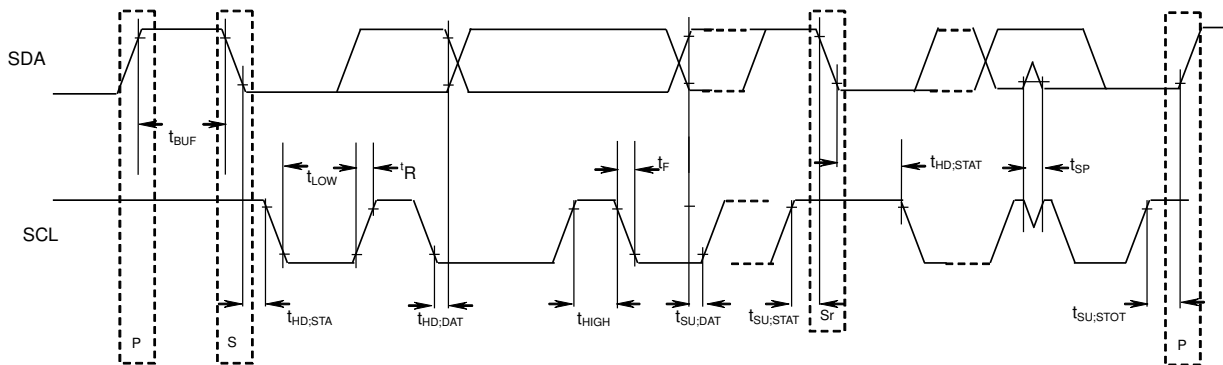


Figure 21. I²C-bus Signal Timing Diagram

Table 1 Characteristics of the SDA and SCL bus lines for I²C-bus devices (Ta=25°C, VCC=8.5V)

Parameter	Symbol	Fast-mode I ² C-bus		Unit
		Min	Max	
1 SCL clock frequency	f _{SCL}	0	400	kHz
2 Bus free time between a STOP and START condition	t _{BUF}	1.3	-	μs
3 Hold time (repeated) START condition. After this period, the first clock pulse is generated	t _{HD:STA}	0.6	-	μs
4 LOW period of the SCL clock	t _{LOW}	1.3	-	μs
5 HIGH period of the SCL clock	t _{HIGH}	0.6	-	μs
6 Set-up time for a repeated START condition	t _{SU:STA}	0.6	-	μs
7 Data hold time:	t _{HD:DAT}	0.06 ^(Note)	-	μs
8 Data set-up time	t _{SU:DAT}	120	-	ns
9 Set-up time for STOP condition	t _{SU:STO}	0.6	-	μs

All values refer to VIH Min and VIL Max Levels (see Table 2).

(Note) A device must internally provide a hold time of at least 300 ns for the SDA signal (referred to the VIH Min of the SCL signal) in order to bridge the undefined region of the falling edge of SCL.
For 7 (t_{HD:DAT}), 8 (t_{SU:DAT}), make the setup in which the margin is full.

Table 2 Characteristics of the SDA and SCL I/O stages for I²C-bus devices

Parameter	Symbol	Fast-mode devices		Unit
		Min	Max	
10 LOW level input voltage:	V _{IL}	-0.3	+1	V
11 HIGH level input voltage:	V _{IH}	2.3	5	V
12 Pulse width of spikes which must be suppressed by the input filter.	t _{SP}	0	50	ns
13 LOW level output voltage: at 3mA sink current	V _{OL1}	0	0.4	V
14 Input current each I/O pin with an input voltage between 0.4V and 4.5V.	I _I	-10	+10	μA

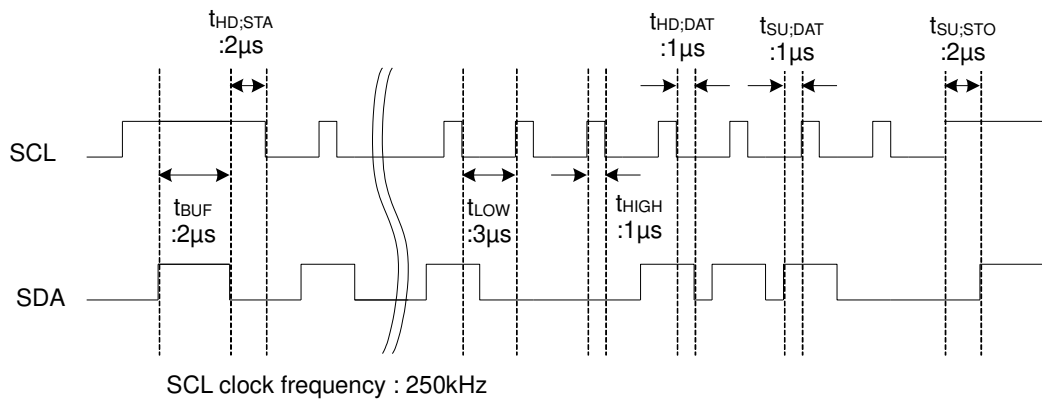


Figure 22. A Command Timing Example in the I²C Data Transmission

(2) I²C BUS FORMAT

MSB	LSB	MSB	LSB	MSB	LSB		
S	Slave Address	A	Select Address	A	Data	A	P
1bit	8bit	1bit	8bit	1bit	8bit	1bit	1bit

- S = Start condition (Recognition of start bit)
- Slave Address = Recognition of slave address. The first 7 bits correspond to the slave address. The least significant bit is "L" which corresponds to write mode.
- A = ACKNOWLEDGE bit (Recognition of acknowledgement)
- Select Address = Select address corresponding to volume, bass or treble.
- Data = Data on every volume and tone.
- P = Stop condition (Recognition of stop bit)

(3) I²C BUS Interface Protocol

(a) Basic Format

S	Slave Address	A	Select Address	A	Data	A	P
MSB	LSB	MSB	LSB	MSB	LSB		

(b) Automatic Increment (Select Address increases (+1) according to the number of data.)

S	Slave Address	A	Select Address	A	Data1	A	Data2	A	...	DataN	A	P
MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB	

- (Example)
- ① Data1 shall be set as data of address specified by Select Address.
 - ② Data2 shall be set as data of address specified by Select Address +1.
 - ③ DataN shall be set as data of address specified by Select Address +N-1.

(c) Configuration Unavailable for Transmission (In this case, only Select Address1 is set.)

S	Slave Address	A	Select Address1	A	Data	A	Select Address 2	A	Data	A	P
MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB


(Note) If any data is transmitted as Select Address 2 next to data, it is recognized as data, not as Select Address 2.

(4) Slave Address

MSB							LSB	
A6	A5	A4	A3	A2	A1	A0	R/W	
1	0	0	0	0	0	0	0	80H

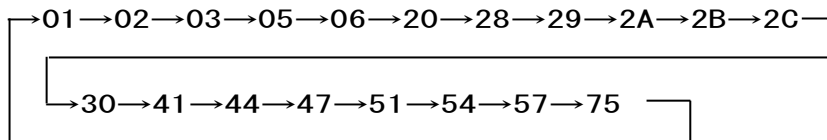
(5) Select Address & Data

Items	Select Address (hex)	Data							
		MSB		Data				LSB	
		D7	D6	D5	D4	D3	D2	D1	D0
Initial setup 1	01	Advanced switch ON/OFF	0	Advanced switch time of Input Gain/Volume Tone/Fader/Loudness Mixing		0	1	Advanced switch time of Mute	
Initial setup 2	02	0	0	Subwoofer Output Select		0	0	0	0
Initial setup 3	03	0	0	0	0	0	0	1	0
Input Selector	05	Full-diff Type	0	0	Input selector				
Input gain	06	Mute ON/OFF	0	0	Input Gain				
Volume gain	20	Volume Gain / Attenuation							
Fader 1ch Front	28	Fader Attenuation							
Fader 2ch Front	29	Fader Attenuation							
Fader 1ch Rear	2A	Fader Attenuation							
Fader 2ch Rear	2B	Fader Attenuation							
Fader Subwoofer	2C	Fader Attenuation							
Mixing	30	Mixing ON / OFF							
Bass setup	41	0	0	Bass fo		0	0	Bass Q	
Middle setup	44	0	0	Middle fo		0	0	Middle Q	
Treble setup	47	0	0	Treble fo		0	0	0	Treble Q
Bass gain	51	Bass Boost/Cut	0	0	Bass Gain				
Middle gain	54	Middle Boost/Cut	0	0	Middle Gain				
Treble gain	57	Treble Boost/Cut	0	0	Treble Gain				
Loudness Gain	75	0	Loudness Hicut		Loudness Gain				
System Reset	FE	1	0	0	0	0	0	0	1

 Advanced switch

Note

1. The Advance Switch works in the latch part while changing from one function to another.
2. Upon continuous data transfer, the Select Address rolls over because of the automatic increment function, as shown below.



3. Advance switch is not used for the function of input selector, subwoofer output select etc. Therefore, please apply mute on the side when changing these settings.
4. When using mute function of this IC at the time of changing input selector, please switch mute ON/OFF for waiting advanced-mute time.

Select address 01 (hex)

Time	MSB Advanced switch time of Mute							LSB	
	D7	D6	D5	D4	D3	D2	D1	D0	
0.6msec	Advanced Switch ON/OFF	0	Advanced switch time of Input gain/Volume Tone/Fader/Loudness Mixing		0	1	0	0	
1.0msec							0	1	
1.4msec							1	0	
3.2msec							1	1	

Time	MSB Advanced switch time of Input gain/Volume/Tone/Fader/Loudness/Mixing							LSB	
	D7	D6	D5	D4	D3	D2	D1	D0	
4.7 msec	Advanced Switch ON/OFF	0	0	0	0	1	Advanced switch Time of Mute		
7.1 msec			0	1					
11.2 msec			1	0					
14.4 msec			1	1					

Mode	MSB Advanced switch ON/OFF							LSB	
	D7	D6	D5	D4	D3	D2	D1	D0	
OFF	0	0	Advanced switch time of Input gain/Volume Tone/Fader/Loudness Mixing		0	1	Advanced switch Time of Mute		
ON	1								

Select address 02(hex)

Mode	MSB Subwoofer Output Select							LSB	
	D7	D6	D5	D4	D3	D2	D1	D0	
Sub	0	0	0	0	0	0	0	0	
Front			0	1					
Rear			1	0					
Prohibition			1	1					

 : Initial Condition

Select address 05(hex)

Mode	OUT		MSB			Input Selector					LSB	
	OUTF1	OUTF2	D7	D6	D5	D4	D3	D2	D1	D0		
A	A1	A2	Full-diff bias type select	0	0	0	0	0	0	0		
B	B1	B2				0	0	0	0	1		
C	C1	C2				0	0	1	0			
D single	DP1	DP2				0	0	1	1			
E1 single	EP1	EN1				0	1	0	1	0		
E2 single	EN2	EP2				0	1	0	1	1		
A diff	A1	B1				0	1	1	1	1		
C diff	B2	C2				1	0	0	0	0		
D diff	DP1	DP2				0	0	1	1	0		
E full diff	EP1	EP2				0	1	0	0	0		
Input SHORT						Other setting					0	1
Prohibition											0	1

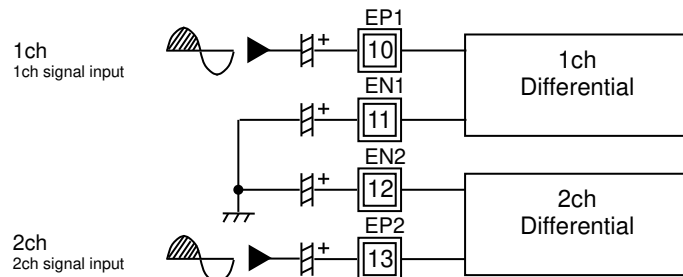
Input SHORT : The input impedance of each input terminal is lowered from 100kΩ(Typ) to 6 kΩ(Typ).
(For quick charge of coupling capacitor)

Mode	MSB			Full-diff Bias Type Select				LSB	
	D7	D6	D5	D4	D3	D2	D1	D0	
Negative Input	0	0	0	Input Selector					
Bias	1								

: Initial condition

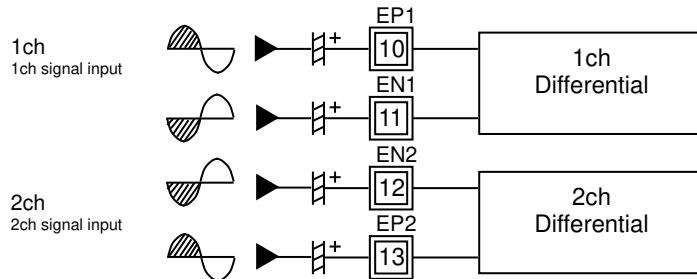
Negative input type

For Ground –isolation type.



Bias type


For differential amplifier type



Select address 06 (hex)

Mode	MSB			Input Gain				LSB
	D7	D6	D5	D4	D3	D2	D1	D0
0dB	Mute ON/OFF	0	0	0	0	0	0	0
1dB				0	0	0	0	1
2dB				0	0	0	1	0
3dB				0	0	0	1	1
4dB				0	0	1	0	0
5dB				0	0	1	0	1
6dB				0	0	1	1	0
7dB				0	0	1	1	1
8dB				0	1	0	0	0
9dB				0	1	0	0	1
10dB				0	1	0	1	0
11dB				0	1	0	1	1
12dB				0	1	1	0	0
13dB				0	1	1	0	1
14dB				0	1	1	1	0
15dB				0	1	1	1	1
16dB				1	0	0	0	0
17dB				1	0	0	0	1
18dB				1	0	0	1	0
19dB				1	0	0	1	1
20dB	1	0	1	0	0			
Prohibition	1	1	0	1	1			
	:	:	:	:	:			
	1	1	1	1	1			

Mode	MSB			Mute ON/OFF				LSB
	D7	D6	D5	D4	D3	D2	D1	D0
OFF	0	0	0	Input Gain				
ON	1							

 : Initial condition

Select address 20, 28, 29, 2A, 2B, 2C (hex)

Gain & ATT	MSB Vol, Fader Gain / Attenuation							LSB	
	D7	D6	D5	D4	D3	D2	D1	D0	
Prohibition	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	1	
	:	:	:	:	:	:	:	:	
	0	1	1	1	0	0	0	0	
15dB	0	1	1	1	0	0	0	1	
14dB	0	1	1	1	0	0	1	0	
13dB	0	1	1	1	0	0	1	1	
:	:	:	:	:	:	:	:	:	
-77dB	1	1	0	0	1	1	0	1	
-78dB	1	1	0	0	1	1	1	0	
-79dB	1	1	0	0	1	1	1	1	
Prohibition	1	1	0	1	0	0	0	0	
	:	:	:	:	:	:	:	:	
	1	1	1	1	1	1	1	0	
-∞dB	1	1	1	1	1	1	1	1	

(Only 0dB to -∞dB are available at address 28, 29, 2A, 2B,2C)

Select address 30(hex)

Gain & ATT	MSB Mixing Gain / Attenuation							LSB	
	D7	D6	D5	D4	D3	D2	D1	D0	
MIX ON	1	0	0	0	0	0	0	0	
MIX OFF	1	1	1	1	1	1	1	1	

Select address 41(hex)

Q factor	MSB Bass Q factor						LSB	
	D7	D6	D5	D4	D3	D2	D1	D0
0.5	0	0	Bass fo		0	0	0	0
1.0							0	1
1.5							1	0
2.0							1	1

fo	MSB Bass fo						LSB	
	D7	D6	D5	D4	D3	D2	D1	D0
60Hz	0	0	0	0	0	0	Bass Q factor	
80Hz			0	1				
100Hz			1	0				
120Hz			1	1				

Select address 44(hex)

Q factor	MSB Middle Q factor						LSB	
	D7	D6	D5	D4	D3	D2	D1	D0
0.75	0	0	Middle fo		0	0	0	0
1.0							0	1
1.25							1	0
1.5							1	1

fo	MSB Middle fo						LSB	
	D7	D6	D5	D4	D3	D2	D1	D0
500Hz	0	0	0	0	0	0	Middle Q factor	
1kHz			0	1				
1.5kHz			1	0				
2.5kHz			1	1				

 : Initial condition

Select address 47 (hex)


Q factor	MSB		Treble				Q factor		LSB
	D7	D6	D5	D4	D3	D2	D1	D0	
0.75	0	0	Treble fo		0	0	0	0	
1.25			0	1					

fo	MSB		Treble fo				LSB	
	D7	D6	D5	D4	D3	D2	D1	D0
7.5kHz	0	0	0	0	0	0	0	Treble Q factor
10kHz			0	1				
12.5kHz			1	0				
15kHz			1	1				

Select address 51, 54, 57 (hex)

Gain	MSB		Bass/Middle/Treble Gain					LSB	
	D7	D6	D5	D4	D3	D2	D1	D0	
0dB	Bass/ Middle/ Treble Boost /cut	0	0	0	0	0	0	0	
1dB				0	0	0	0	1	
2dB				0	0	0	0	1	0
3dB				0	0	0	0	1	1
4dB				0	0	0	1	0	0
5dB				0	0	1	0	1	1
6dB				0	0	1	1	1	0
7dB				0	0	1	1	1	1
8dB				0	1	0	0	0	0
9dB				0	1	0	0	0	1
10dB				0	1	0	1	0	0
11dB				0	1	0	1	1	1
12dB				0	1	1	0	0	0
13dB				0	1	1	1	0	1
14dB				0	1	1	1	1	0
15dB				0	1	1	1	1	1
16dB				1	0	0	0	0	0
17dB				1	0	0	0	0	1
18dB				1	0	0	1	0	0
19dB				1	0	0	1	1	1
20dB	1	0	1	0	0	0			
Prohibition	1	0	1	0	1	0	1		
	:	:	:	:	:	:			
	1	1	1	1	1	0			
	1	1	1	1	1	1			


Mode	MSB		Bass/Middle/Treble Boost/Cut					LSB
	D7	D6	D5	D4	D3	D2	D1	D0
Boost	0	0	0	Bass/Middle/Treble Gain				
Cut	1							

 :Initial condition

Select address 75 (hex)

Mode	MSB			Loudness Hicut				LSB	
	D7	D6	D5	D4	D3	D2	D1	D0	
Hicut1	0	0	0	Loudness Gain					
Hicut2		0	1						
Hicut3		1	0						
Hicut4		1	1						

Gain	MSB			Loudness Gain				LSB	
	D7	D6	D5	D4	D3	D2	D1	D0	
0dB	0	Loudness Hicut		0	0	0	0	0	
1dB				0	0	0	0	1	
2dB				0	0	0	1	0	
3dB				0	0	0	1	1	
4dB				0	0	1	0	0	
5dB				0	0	1	0	1	
6dB				0	0	1	1	0	
7dB				0	0	1	1	1	
8dB				0	1	0	0	0	
9dB				0	1	0	0	1	
10dB				0	1	0	1	0	
11dB				0	1	0	1	1	
12dB				0	1	1	0	0	
13dB				0	1	1	0	1	
14dB				0	1	1	1	0	
15dB				0	1	1	1	1	
16dB				1	0	0	0	0	
17dB				1	0	0	0	1	
18dB				1	0	0	1	0	
19dB				1	0	0	1	1	
20dB	1	0	1	0	0				
Prohibition	:	:	:	:	:				
	1	1	1	1	1				

 : Initial condition

(6) About Power ON Reset

Built-in IC initialization is made during power ON of the supply voltage. Please send initial data to all addresses at supply voltage on. And please turn ON mute until this initial data is sent.

Parameter	Symbol	Limit			Unit	Conditions
		Min	Typ	Max		
Rise Time of VCC	t _{RISE}	33	-	-	μsec	V _{CC} rise time from 0V to 5V
VCC Voltage of Release Power ON Reset	V _{POR}	-	4.1	-	V	

(7) About External Compulsory Mute Terminal

It is possible to force mute externally by setting an input voltage to the MUTE terminal.

Mute Voltage Condition	Mode
GND to 1.0V	MUTE ON
2.3V to V _{CC}	MUTE OFF

Establish the voltage of MUTE in the condition you want to set.

Application Information

1. Function and Specifications

Function	Specifications																												
Input selector	<ul style="list-style-type: none"> · Stereo input · Single-End/Diff/Full-Diff (Possible to set the number of single-end/diff/full-diff as follows) <table border="1"> <thead> <tr> <th></th> <th>Single-End</th> <th>Differential</th> <th>Full-Differential</th> </tr> </thead> <tbody> <tr> <td>Mode 1</td> <td>0</td> <td>3</td> <td>1</td> </tr> <tr> <td>Mode 2</td> <td>1</td> <td>2</td> <td>1</td> </tr> <tr> <td>Mode 3</td> <td>3</td> <td>1</td> <td>1</td> </tr> <tr> <td>Mode 4</td> <td>4</td> <td>0</td> <td>1</td> </tr> <tr> <td>Mode 5</td> <td>5</td> <td>1</td> <td>0</td> </tr> <tr> <td>Mode 6</td> <td>6</td> <td>0</td> <td>0</td> </tr> </tbody> </table> <p>Table.1 Combination of input selector</p>		Single-End	Differential	Full-Differential	Mode 1	0	3	1	Mode 2	1	2	1	Mode 3	3	1	1	Mode 4	4	0	1	Mode 5	5	1	0	Mode 6	6	0	0
	Single-End	Differential	Full-Differential																										
Mode 1	0	3	1																										
Mode 2	1	2	1																										
Mode 3	3	1	1																										
Mode 4	4	0	1																										
Mode 5	5	1	0																										
Mode 6	6	0	0																										
Input gain	<ul style="list-style-type: none"> · +20dB to 0dB (1dB step) · Possible to use "Advanced switch" for prevention of switching noise. 																												
Mute	<ul style="list-style-type: none"> · Possible to use "Advanced switch" for prevention of switching noise. 																												
Volume	<ul style="list-style-type: none"> · +15dB to -79dB (1dB step), -∞dB · Possible to use "Advanced switch" for prevention of switching noise. 																												
Bass	<ul style="list-style-type: none"> · +20dB to -20dB (1dB step) · Q=0.5, 1, 1.5, 2 · $f_0 = 60, 80, 100, 120\text{Hz}$ · Possible to use "Advanced switch" for prevention of switching noise. 																												
Middle	<ul style="list-style-type: none"> · +20dB to -20dB (1dB step) · Q=0.75, 1, 1.25, 1.5 · $f_0 = 500, 1\text{k}, 1.5\text{k}, 2.5\text{kHz}$ · Possible to use "Advanced switch" for prevention of switching noise. 																												
Treble	<ul style="list-style-type: none"> · +20dB to -20dB (1dB step) · Q=0.75, 1.25 · $f_0 = 7.5\text{k}, 10\text{k}, 12.5\text{k}, 15\text{kHz}$ · Possible to use "Advanced switch" for prevention of switching noise. 																												
Fader	<ul style="list-style-type: none"> · 0dB to -79dB, -∞dB · Possible to use "Advanced switch" for prevention of switching noise. 																												
Loudness	<ul style="list-style-type: none"> · 20dB to 0dB(1dB step) · Possible to use "Advanced switch" for prevention of switching noise. 																												
Mixing	<ul style="list-style-type: none"> · Monaural input · 0dB/-∞dB · Possible to use "Advanced switch" for prevention of switching noise. 																												

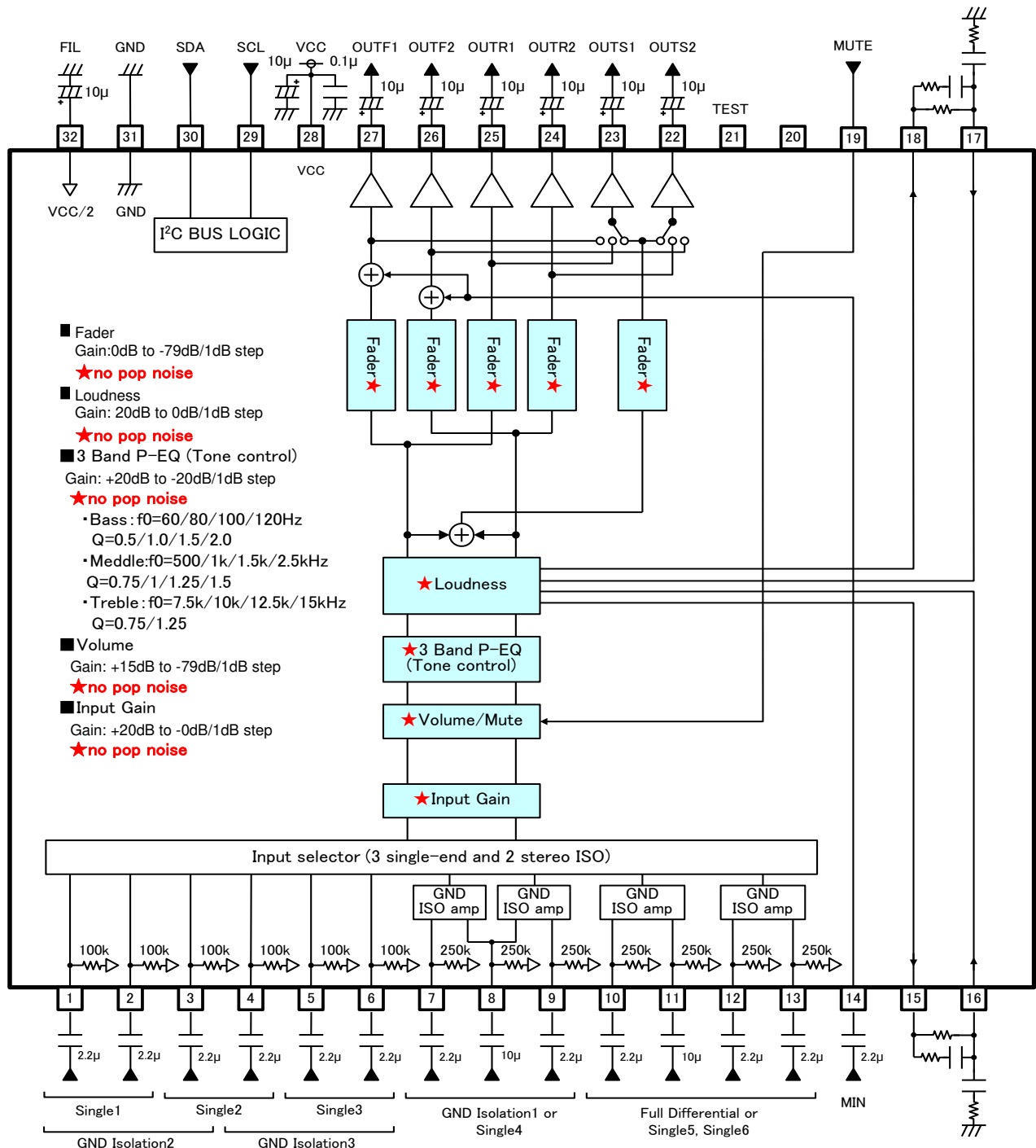
2. Volume / Fader Volume Attenuation Data

(dB)	D7	D6	D5	D4	D3	D2	D1	D0	(dB)	D7	D6	D5	D4	D3	D2	D1	D0
+15	0	1	1	1	0	0	0	1	-33	1	0	1	0	0	0	0	1
+14	0	1	1	1	0	0	1	0	-34	1	0	1	0	0	0	1	0
+13	0	1	1	1	0	0	1	1	-35	1	0	1	0	0	0	1	1
+12	0	1	1	1	0	1	0	0	-36	1	0	1	0	0	1	0	0
+11	0	1	1	1	0	1	0	1	-37	1	0	1	0	0	1	0	1
+10	0	1	1	1	0	1	1	0	-38	1	0	1	0	0	1	1	0
+9	0	1	1	1	0	1	1	1	-39	1	0	1	0	0	1	1	1
+8	0	1	1	1	1	0	0	0	-40	1	0	1	0	1	0	0	0
+7	0	1	1	1	1	0	0	1	-41	1	0	1	0	1	0	0	1
+6	0	1	1	1	1	0	1	0	-42	1	0	1	0	1	0	1	0
+5	0	1	1	1	1	0	1	1	-43	1	0	1	0	1	0	1	1
+4	0	1	1	1	1	1	0	0	-44	1	0	1	0	1	1	0	0
+3	0	1	1	1	1	1	0	1	-45	1	0	1	0	1	1	0	1
+2	0	1	1	1	1	1	1	0	-46	1	0	1	0	1	1	1	0
+1	0	1	1	1	1	1	1	1	-47	1	0	1	0	1	1	1	1
0	1	0	0	0	0	0	0	0	-48	1	0	1	1	0	0	0	0
-1	1	0	0	0	0	0	0	1	-49	1	0	1	1	0	0	0	1
-2	1	0	0	0	0	0	0	1	-50	1	0	1	1	0	0	1	0
-3	1	0	0	0	0	0	1	1	-51	1	0	1	1	0	0	1	1
-4	1	0	0	0	0	1	0	0	-52	1	0	1	1	0	1	0	0
-5	1	0	0	0	0	1	0	1	-53	1	0	1	1	0	1	0	1
-6	1	0	0	0	0	1	1	0	-54	1	0	1	1	0	1	1	0
-7	1	0	0	0	0	1	1	1	-55	1	0	1	1	0	1	1	1
-8	1	0	0	0	1	0	0	0	-56	1	0	1	1	1	0	0	0
-9	1	0	0	0	1	0	0	1	-57	1	0	1	1	1	0	0	1
-10	1	0	0	0	1	0	1	0	-58	1	0	1	1	1	0	1	0
-11	1	0	0	0	1	0	1	1	-59	1	0	1	1	1	0	1	1
-12	1	0	0	0	1	1	0	0	-60	1	0	1	1	1	1	0	0
-13	1	0	0	0	1	1	0	1	-61	1	0	1	1	1	1	0	1
-14	1	0	0	0	1	1	1	0	-62	1	0	1	1	1	1	1	0
-15	1	0	0	0	1	1	1	1	-63	1	0	1	1	1	1	1	1
-16	1	0	0	1	0	0	0	0	-64	1	1	0	0	0	0	0	0
-17	1	0	0	1	0	0	0	1	-65	1	1	0	0	0	0	0	1
-18	1	0	0	1	0	0	1	0	-66	1	1	0	0	0	0	1	0
-19	1	0	0	1	0	0	1	1	-67	1	1	0	0	0	0	1	1
-20	1	0	0	1	0	1	0	0	-68	1	1	0	0	0	1	0	0
-21	1	0	0	1	0	1	0	1	-69	1	1	0	0	0	1	0	1
-22	1	0	0	1	0	1	1	0	-70	1	1	0	0	0	1	1	0
-23	1	0	0	1	0	1	1	1	-71	1	1	0	0	0	1	1	1
-24	1	0	0	1	1	0	0	0	-72	1	1	0	0	1	0	0	0
-25	1	0	0	1	1	0	0	1	-73	1	1	0	0	1	0	0	1
-26	1	0	0	1	1	0	1	0	-74	1	1	0	0	1	0	1	0
-27	1	0	0	1	1	0	1	1	-75	1	1	0	0	1	0	1	1
-28	1	0	0	1	1	1	0	0	-76	1	1	0	0	1	1	0	0
-29	1	0	0	1	1	1	0	1	-77	1	1	0	0	1	1	0	1
-30	1	0	0	1	1	1	1	0	-78	1	1	0	0	1	1	1	0
-31	1	0	0	1	1	1	1	1	-79	1	1	0	0	1	1	1	1
-32	1	0	1	0	0	0	0	0	-∞	1	1	1	1	1	1	1	1

Fader Volume only 0dB to -∞dB are available.

 : Initial condition

3. Application Circuit



(Note) About single input 1 to 3, it is possible to change from single input to GND Isolation input 2,3.

(Note) About GND Isolation1 and Full Differential, it is possible to change from differential input to single input 4 to 6.

Unit
 R : [Ω]
 C : [F]

Figure 23. BD37541FS

- Notes on wiring**
- ① Please connect the decoupling capacitor of the power supply in the shortest possible distance to GND.
 - ② GND lines should be one-point connected.
 - ③ Wiring pattern of Digital should be away from that of Analog unit and crosstalk should not be acceptable.
 - ④ SCL and SDA lines of I²C BUS should not be parallel if possible.
 The lines should be shielded, if they are adjacent to each other.
 - ⑤ Analog input lines should not be parallel if possible. The lines should be shielded, if they are adjacent to each other.
 - ⑥ About TEST pin (Pin 21), please leave it OPEN.

Power Dissipation

About the thermal design of the IC

Characteristics of an IC have a great deal to do with the temperature at which it is used, and exceeding absolute maximum ratings may degrade and destroy elements. Careful consideration must be given to the heat of the IC from the two standpoints of immediate damage and long-term reliability of operation.

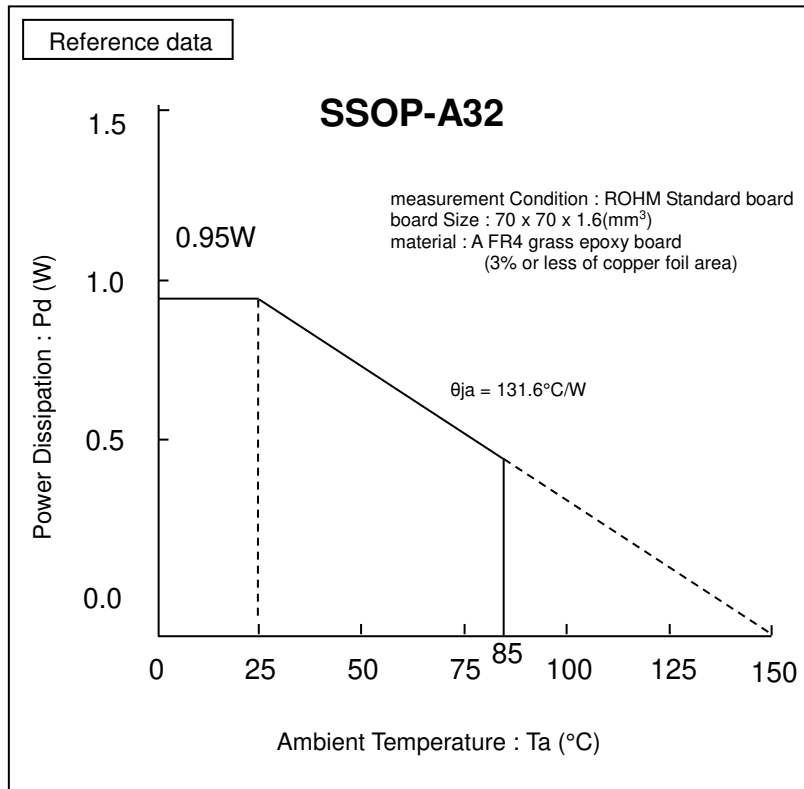


Figure 24. Temperature Derating Curve

(Note) Values are actual measurements and are not guaranteed.

Power dissipation values vary according to the board on which the IC is mounted.

I/O Equivalent Circuits

Terminal No.	Terminal Name	Terminal Voltage	Equivalent Circuit	Terminal Description
1 2 3 4 5 6	A1 A2 B1 B2 C1 C2	4.25		A terminal for signal input. The input impedance is 100kΩ (typ).
7 8 9 10 11 12 13	DP1 DN DP2 EP1 EN1 EN2 EP2	4.25		Input terminal available to Single/Differential mode. The input impedance is 250kΩ (typ).
15 18	LDA1 LDA2	4.25		The loudness characteristic setting terminal.
16 17	LDB1 LDB2	4.25		The loudness characteristic setting terminal.
19	MUTE	-		A terminal for external compulsory mute. If terminal voltage is High level, the mute is OFF. And if the terminal voltage is Low level, the mute is on.

Values in the pin explanation and input/output equivalent circuit are reference values only and are not guaranteed.